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ABSTRACT

Some basic concepts and types of computer assisted instruction (CAI) are presented, and their application in college and university settings is considered. CAI literature of the late 1960's--including descriptions of specific CAI systems together with studies of instructional effectiveness, learning time, and student attitudes--is then summarized. The appendix contains abstracts of numerous pre-1970 comparative studies on CAI. (DGC)

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Computer-Assisted Instruction: Potential for College Level Instruction and Review of Research

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UDIS
May 25, 1970

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Section 1

What is Computer-Assisted Instruction?

Computer-assisted instruction (CAI) is a process of individualizing instruction, that is, a set of procedures in which the computer is employed to control the selection, sequencing and evaluation of learning materials. In this manner CAI not only facilitates the instructor's work but also enables every student to have the equivalent of private, individualized instruction. CAI has the potential to: a. accelerate learning process, b. augment conventional teaching methods, c. to serve experimentally in developing educational courses, d. provide remedial teaching measures, and e. assist in achieving consistently higher teaching standards.

In achieving these objectives, a CAI system depends on the ability of the computer to provide two significant capabilities:

1. Memory. The computer provides a detailed record of students' responses to individualized displays of instructional materials in a form directly useful for automatic processing. For example, the computer can gather, store, and process information about individual students and their choices, performances, and route through instructional material.

2. Logic. The computer has the capability to make the organization of instructional information dependent upon characteristics of the individual. It is versatile in that it can be programmed to be responsive, i.e., to adapt and modify the teaching logic in response to student performance and background.

Thus, it appears that there are some things which CAI is able to do better than any other media:

1. secure, store and process information about the students' performance prior to and/or during instruction to determine subsequent activities in the learning situation.

2. store large amounts of information and make it available to the learner more rapidly than any other media.

3. provide programmed control of several media such as films, slides, TV, and demonstration equipment.

4. give the author or teacher an extremely convenient technique for designing and developing a course of instruction.

5. provide a dynamic interaction between student and an instructional program not possible with most other media.

The basic principle of CAI is that each student can learn according to his own particular requirements. This not only means that each student can learn as quickly as possible, but also that the amount and content of material presented can be tailored to his individual needs. Using this system, students who are able to grasp and retain subject matter with a minimum amount of explanation and drill can advance to new material in accordance with their ability. Slower students can be directed to alternate presentations, drill, and exercises that allow them to learn at a slower pace.

The IBM 1500 Instructional System is a versatile tool for computer-assisted instruction. As many as 32 students, each working independently on a different problem, can share the system at any one time. Textual material, black-and-white or full-color pictures, and audio messages can be presented to students a individual instructional stations. The course author can specify which material is to be presented as a result of analysis made by the computer during instruction. For example, a course author can direct that a student skip an entire section if his responses to early questions indicate that he already knows the material in that section. He can also direct a slower student to a remedial section of instruction if his responses indicate a weakness in a particular area. All analysis and transferring to sections is performed automatically by CAI application programs associated with the operating system, which controls all computer activity and all interaction between students and course material during instruction. The operating system receives its directions from information the author has provided it through a special education-oriented language call Coursewriter II.

In a well-prepared program the student progresses according to his individual capabilities. The more capable student moves faster because he makes fewer errors or otherwise meets author/teacher-defined performance criteria. The slower student requires more practice and in some cases more information to achieve an acceptable level of understanding. It is the course author's responsibility to plan his presentation so that each student is directed through the course material that best suits his learning pattern. Coursewriter programs are made up of instructions that specify what course material is to be given and control the sequence or its presentation to individual students.

1. present textual material on the typewriter or display screen.
2. ask questions.
3. process student responses
4. operate the audio and image projector units.
5. perform arithmetic and logical operations.

The most significant part of any computer-assisted instruction application is the design of the course material and the method used to present it to the student. Eight general modes of CAI utilization have been identified as having potential for improving student achievement in varied types of learning situations.

1. Drill and practice assumes that students need a great deal of practice in order to master certain basic knowledge, procedures, vocabulary, nomenclature, or mathematical skills. Drills to provide this practice can be presented by the computer in a fairly standardized fashion and the patterns for student-computer interaction are generally limited to simple correction and retrial.

   Utilizing its extensive memory, its endless patience, and its ability to adapt to student performance, this mode of computer use has been very effective. Instruction can be modified to meet the needs of each student both as to level of difficulty and rate of presentation. This potential to individualize instruction is a very strong argument for developing the use of CAI.

2. Tutorial programs can utilize a variety of question-and-answer sequences, presentation of reading passages, and so forth, simulating student-tutor interaction. Instructional sequences that use remedial and skip-ahead pathways selected on the basis of previous student responses are incorporated extensively by computer programs to move the student toward the attainment of a set of specifically defined teaching objectives. The important factor here is the kind of responsibility assumed by the teacher for the kinds of interactions which occur during the instructional experience.

3. Sumulation provides the establishment of an artificial but realistic physical, mathematical, or social environment and is responsive to decisions made by the student as he receives information at the terminal. The interaction and feedback information provided by the constantly changing configuration of the system enables the student to learn how to modify his responses to achieve a desired objective. In most instances, prior knowledge of skills and concepts is assumed so that the student can deal with more complex "environment" created by the computer. The laboratory sequences would fall into this catagory.

   To implement this mode of CAI the teacher must define the model sufficiently to permit it to be programmed. A computer program must be written to

process the student's input so that he gets a meaningful output. The output is determined by what the student does and by the program. The student interacts by using natural language.

4. The inquiry mode is the fourth type of CAI application. In this mode the CAI system responds to the student inquiry with answers it has stored in its files to the extent that the algorithms it contains provide access to that information. In this mode, the instructional staff must learn how the system operates in order to establish files and search algorithms that anticipate student questions.

5. Gaming simulation is less akin to a real life situation. The student can play actual problem-oriented games which enable him to make decisions about complicated set situations. Alternative choices are limited to the relationships that the computer is programmed to describe.

6. Problem-solving applications require that the student learn algorithmic or algebraic computer languages to use the computer's information file to retrieve and display data. This is a resource that permits the student to use the computer as a problem-solving and exploratory tool. In some instances a mathematical language may be used.

7. Computer-Aided Laboratories. The computer can be used at least three ways in the laboratory.

   First, it can be used principally as a guide to present the student with problems that he solves at the laboratory bench and then types into the terminal for verification. At this point; he is branced to one of a variety of subsequent operations depending upon the adequacy of his responses.

8. Testing, Recording and Processing Student Performance.

   As indicated previously, the potential of CAI to undertake the assessment of student performances is a key element in individualizing instruction. The computer can be of considerable assistance to the teacher in keeping accurate and comprehensive records on individual student performance, regardless of the method of instruction used. The assessment of student performance also includes testing of a formal nature as well as collecting data on daily performance. Again the computer can be used for this activity. The testing can be quite sophisticated and results made known to the student immediately.

> By comparing response types, errors, and other performance data with detailed instructional guidelines established by the course author, the computer is able to tailor subsequent material to the capability of the student. In fact, the analysis of performance data may suggest ways in which the instructor might enrich his course material or reveal students for whom specialized help appears desirable.

At the Computer Assisted Instruction Laboratory, College of Education, The Pennsylvania State University, the IBM 1500 CAI system is in use. With this system it is possible to develop and present college level courses that:

1. Present material through the most appropriate medium, i.e., display screen, image projector, or audio unit.

2. Receive student responses of varying types and lengths--from one character to phrases and sentences.

3. Include questions of varying degrees of complexity.

4. Present remedial material to students whose responses show weakness in specific areas.

5. Present additional advanced material to students with exceptional learning abilities.

6. Present drill exercises to reinforce material learned in earlier sessions.

7. Evaluate each student's response immediately after he enters it and change the sequence of presentation as a result of this evaluation.

8. Keep student motivation at a high level by keeping each student informed of his progress.

9. Ensure that each student moves ahead only when his responses indicate that he has an adequate grasp of the material which has already been presented.

10. Test the student's progress at appropriate points in the lesson.

Section II

Review of Instructional Research on CAI*

A. Comparative Studies

Axeen (1967) developed and evaluated a program on how to use the library employing the PLATO system. She concluded that use of the library could be taught with CAI. CAI and conventional classroom students both made significant gains, but the difference between groups was not significant. Students learned faster on CAI; PLATO lessons took much more time to prepare than lectures; and subsequent use of PLATO instruction saved time as compared with conventional instruction.

Ash and Moller (1967) programmed a unit of material on terminology and concepts in modern mathematics and administered it to 16 college sophomore Ss on CAI in approximately two 45-minute sessions while 16 Ss received live classroom instruction on the same material. While the CAI Ss had a higher mean on the post test (15 vs 23) than the controls, the difference was not significant. Attitudinal evaluation should 30 percent of the CAI Ss favored CAI over tradtional teaching, 27 percent were neutral, and 43 percent favored traditional lectures and discussions.

Bitzer (1966) studied the use of PLATO for instruction in clinical aspects of medical-surgical nursing. Seven freshman in nursing were taught with a CAI inquiry program while sevel received live clinical instruction. The mean Post-test score for the CAI Ss was 26, for the control group, 23, and the difference was significant at the .09-level. Student attitudinal evaluation revealed that the following were perceived advantages of CAI: (1) active participateion, (2) individual rates of progress, (3) immediate feedback, and (4) simulation of work with patients.

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*Adapted with few changes from: John Feldhusen and Michael Szabo, "The Advent of the Educational Heart Transplant, Computer-Assisted Instruction: A Brief Review of Research," Contemporary Education, 1969, 40

Axeen, Marina E. Teaching the use of the library to undergraduates; An experimental comparison of computer-assisted instruction and the conventional lecture method. A technical report, Coordinated Science Laboratory, University of Illinois, Report R-361, 1967.

Ash, W. and Moller, Nancy Learning modern mathematics--conventional vs computer-assisted instruction. A technical report, Educational Psychology Section, Purdue University, 1967 (mimeo).

Bitzer, Maryann. Clinical nursing instruction via the PLATO simulated laboratory. Nursing Research, 1966, 15, 1-7.

Schurdak (1967) studied the effects of a CAI program, a programmed text, and a conventional textbook-workbook combination in teaching Fortran programming to 48 college students, 16 per treatment. The CAI group scored significantly higher than the other two groups.

Schwartz and Haskell (1966) used a CAI program for training electronic technicians in basic data-processing. A standard programmed instruction unit (PI) for the same purpose was already in use. The PI unit was used with 79 Ss and the CAI with 25 Ss. Post-test means did not differ between groups. It took 22 hours for the CAI group to complete the instruction. This was significantly less time than it took students who received the programmed unit (25 hours). Both groups saw the method PI or CAI as about equal to regular classroom instruction for learning and interest.

Schwartz and Long (1967) compared a self-study program on introduction to computeres with a CAI program on the same subject. Forty IBM field engineers served as Ss, 16 on self-study and 24 on CAI. The difference between the mean performances of the two groups on the post test was judged to be on no practical significance, but CAI Ss took significantly less time in the training as a whole. All students in both groups had been exposed to CAI, and overall they indicated a preference for CAI over self-study.

O'Neal (1968) summarized IBM's Field Engineering CAI applications Research during 1967. Six training areas were studied and eleven separate projects were run evaluating post test performance, time to complete, and attitudes. Significant differences were found in favor of CAI in time to complete three of the courses and in attitudes toward two of the courses.

Schurdak, J. J. An approach to the use of computers in the instructional process and an evaluation. American Educational Research Journal, 1967, 4, 59-73.

Schwartz, H. A. and Haskell, R. J. A Study of computer-assisted instruction in industrial training. Journal of Applied Psychology, 1966, 50, 360-363.

Schwartz, H. A. and Long, H. S. A Study of remote industrial training via computer-assisted instruction. Journal of Applied Psychology, 1967, 51, 11-16.

O'Neal, L. R. CAI applications research in IBM field engineering education. A technical report from IBM's Systems Development Division, Poughkeepsie, New York, 1968.

Feldhusen and Chavers (1968) reported results on the use of CAI to teach graduate students in teacher education the Flanders classroom interaction analysis system. The program was in tutorial form written in Coursewriter language and took two to three hours per student. Slides were used in addition to keyboard input and output. CAI students' achievement was not significantly higher than self-study students who studied a specially prepared manual. However, CAI students and students who used the self-study manual scored significantly higher than controls who received no instruction.

Adams, Morrison and Reddy (1967) described a CAI language laboratory designed to teach speaking, understanding, reading and writing in a first year college German course. Preliminary evaluations provided no data on student achievement but indicated that the program was regarded by the instructor and students as successful functionally. In a later report by Morrison and Adams (1967), evaluative data was reported which indicated that students in the CAI German program, when compared with a class taught by a live instructor who used the audio-lingual method and a language lab, scored higher on a writing achievement test at the end of the first semester, but there were no significant differences between groups at the end of the second semester on tests of speaking, listening, and reading.

Filep and Murphy (1967) described the development and evaluation of a computer-assisted learning (CAL) system for in-service education of high school biology teachers. Teachers used the terminals before and after the normal school day and weekends. CAL teachers (N=23) were compared with an uninstructed control group of 11 teachers. The CAL group outscored the controls on three achievement tests, and it was concluded that the attitude of the CAL group toward the innovation was favorable.

Feldhusen, J. F. and Chavers, Elaine. Evaluation of a CAI program to teach the Flanders Interaction Analysis system. A technical report, Educational Psychology Section, Purdue University, 1968 (mimeo).

Adams, E. N., Morrison, H. W. and Reddy, J. M. Conversation with a computer as a technique of language instruction. IBM Research Paper, RC-1815, IBM Watson Research Center, Yorktown Heights, New York, 1967.

Morrison, H. W. and Adams, E. N. Pilot study of a CAI laboratory in German. IBM Research Paper, RC-1974, IBM Watson Research Center, Yorktown Heights, New York, 1967.

Filep, R. T. and Murphy, D. B. Computer-assisted learning for in-service teacher education. Technical Memorandum--(L)--3494, Systems Development Corporation, Santa Monica, California, 1967.

Grubb and Selfridge (1962) reported a pioneering research on the use of CAI in teaching psychological statistics. Six students received CAI, eight received lectures, and eight programmed text. The CAI group took 5.3 hours, the lecture group 49 hours, and the programmed text group 12.2 hours. Comparative achievement data was available only for the CAI and lecture groups. The results indicated that the CAI group outperformed the lecture group.

Johnson and Borman (1967) evaluated three types of stimulus presentations in CAI. (a) typewritten, (b) audio, and (c) booklet. Ninety Ss were involved in the study; the number of Ss in each of the treatment groups (three experimental and one control) were unequal. The instruction consisted of about one hour of material on physics. All three experimental groups scored significantly higher on the posttest than did the control group, but there were no significant differences among the three experimental methods.

B. Individual Differences (ID) and CAI

Mitzel (1967) presented a final report on the development and evaluation of four college courses developed for CAI. Evaluations were run for high and low ability students. The courses included audiology, accounting, economics, and modern mathematics. Comparisons of CAI with control group achievement were made for only two of the courses, and these results revealed no significant differences. However, the high aptitude subjects had significantly higher post test scores, fewer program errors, took less time on the programs, and developed more favorable attitudes toward CAI than low aptitude subjects.

Grubb, R. E. and Selfridge, L. D. The computer tutoring of statistics: A preliminary report. IBM Research Report, RC-724, Thomas J. Watson Research Center, Yorktown Heights, New York, 1962.

Johnson, D. W. and Borman, K. G. Relative effectiveness of various modes of stimulus presentation through computer-assisted instruction. In H. E. Mitzel and G. L. Brandon (Eds.) Experimentation with computer-assisted instruction in technical education. Project Report No. 5-58-074, Pennsylvania State University, 1967, 27-40.

Mitzel, H. E. The development and presentation of four college courses by computer teleprocessing. Final technical report of OE contract No. 4-16-010. Pennsylvania State University, University Park, 1967.

Brown and Bahn (1968) studied the effects of prior knowledge of the subject matter on learning from CAI programs on modern mathematics which did or did not make provision for pre-existing individual differences. There were 32 and 33 Ss in the two treatments respectively. Ss' level of prior knowledge was measured. Ss with prior knowledge of the subject scored significantly higher on the post and retention tests than those with no prior knowledge in the treatment which provided specific provision for these IDs. Ss who had prior knowledge took significantly less time in the program in the treatment which provided for IDs than in the treatment which did not.

Gilman and Gargula (1967) in the study on modes of feedback, found that low ability Ss took more time to do the program than high ability Ss.

Silberman, et. al. (1960) found that student aptitude was significantly and positively correlated with post test scores in both linear and branching programs and negatively correlated with time to do the program and number of errors in both methods.

In the study by Coulson, et. al. (1962), in which significant differences were found favoring the branching group on the post test, correlations between aptitude and post test scores were not significant in either the linear or the branching group.

In the previously cited study by Wodtke, et. al. (1962), in which significant differences were found favoring the branching group on the post test, correlations between aptitude and post test scores were not significant in either the linear or the branching group.

Brown, B. R. and Bahn, T. A. Prior knowledge and individualized instruction. In H.E. Mitzel and G.L. Brandon (Eds.) Experimentation with computer-assisted instruction in technical education. Project Report No. 5-85-074, Pennsylvania State University, 1968, 1-15.

Gilman, D. A. and Gargula, Clara. Remedial and Review Branching in computer-assisted instruction. In H.E. Mitzel and G.L. Brandon (Eds.) Experimentation with computer assisted instruction in technical education. Project Report No. 5-85-074, Pennsylvania State University, 1967, 49-58.

Silberman, H. G., Coulson, J. E., Melaragno, R. J. and Eastavan, D. P. Fixed sequence vs. branching in computer-based teaching machine. Systems Development Corporation, Sp-195, 1960.

Coulson, J. E., Estavan, D. P., Melaragno, R. J., and Silberman, H. G. Effects of branching in a computer controlled auto-instructional device. Journal of Applied Psychology, 1962, 46, 389-92.

Wodtke, K. H., Brown, B. R., Sands, H. R., and Frederick, Patricia. The effects of subject matter and individual differences on economy from scrambled nos. ordered instructional programs, a paper given at the American Educational Research Association annual meeting, 1968.

O'Neil, Spielberger and Hansen (1968) used a CAI program on complex numbers and compound fractions which could be completed in one sitting with undergraduate Ss who were given an anxiety-inducing message when they arrived. The program was divided into a hard and an easy part. They found that Ss responded to difficult CAI materials with an increase in self-reported anxiety and physiologically measured anxiety (blood pressure) and that high-anxiety Ss made more errors in the difficult portion of the program than low-anxiety Ss while low-anxiety Ss made more errors on the easy part.

Wodtke, Mitzel and Brown (1965) found that low achievers found instruction on a remote CAI terminal to be too rapid.

The most extensive CAI tutorial experiments were performed by Wodtke (1965) at The Pennsylvania State University. The first experiment focused on the effects of scrambling the implicit sequence of a set of mathematical concepts. Randomizing the sequence of the material led the college students to make more errors in working through the program and to require more instructional time to complete the course. This increase in latencies on individual questions led to a decrease in efficiency of instruction as indicated by the amount learned per unit time. The scrambling of the material interfered most with the learning of the high-aptitude students. This negative effect on the high-aptitude students was also expressed in the students' self-reports on an anxiety scale. In a second study Wodtke (1965) also had college students work via CAI through a modern mathematics program and found significant correlations between general intelligence and other aptitude measures with their performance on the CAI course material. This finding is the reverse of that found in many programmed instruction experiments. Attitude measures about CAI, although positive, did not vary significantly with any of the CAI achievement outcomes. This series of studies at The Pennsylvania State University indicates the uses CAI couse materials can have as media by which to investigate instructional variables.

O'Neil, H. F., Spielberger, C. D. and Hansen, D. N. State anxiety and task difficulty using CAI media. A paper given at the American Educational Research Association annual meeting, 1968.

Wodtke, K. H., Mitzel, H. E., and Brown, B. R. Some preliminary results on the reactions of students to computer-assisted instruction. A paper given at the American Psychological Association annual meeting, 1965.

Wodtke, K. H. "Preliminary Research Findings". Experimentation with Computer-Assisted Instruction in Technical Education. (Edited by Harold E. Mitzel and George L. Brandon.) University Park: Computer Assisted Instruction Laboratory, Pennsylvania State University, 1965, 25-41.

Stolurow and Davis (1965) reviewed studies of the interaction of ID variables with method of instruction and concluded that such interactions do, in fact, occur in a variety of instructional settings and methods. They also suggest that CAI will be a tremendous aid in conducting research on ID-method interactions and in implementing instruction which matches student with method.

C. Basic Learning Studies in CAI

Hall, Adams, and Tardibuono (1968) studied the effects of providing feedback in the form of the full correct response when an error was made or of pointing out matching letters of the alphabet between the correct answer and that given by the student. Undergraduate Ss learned states and capital cities. The group who received full response feedback took significantly less time to complete the program, but the amount learned did not differ significantly between groups.

Gilman (1968a, 1968b) studied the effects of five types of feedback in a multiple-choice response mode CAI program: (A) no feedback, (B) knowledge of results or merely saying "correct" or "wrong" to the student (C) identification of the letter of the correct answer, (D) explanation of correct answer, and (E) B, C, and D combined. There were 15 Ss in each group who were instructed with a CAI program on general science concepts. Ss were stratified with a mental ability measure. Ss in groups D and E experienced significantly more cetrainty about the correctness of their responses prior to feedback than Ss in A and B, Ss in groups C, D, and E earned significantlt higher post test scores than Ss in A and B, but there were no differences among groups in attitude toward the methods of instruction.

Stolurow, L. M. and Davis, D. Teaching machines and computer-based systems. In R. Glaser (Ed.) Teaching machines and programmed learning II, Data and Directions. Washington, D. C.: Department of Audio-Visual Instruction of the National Education Association, 1965, 162-212.

Hall, K. A., Adams, M., and Tardibuono, J. Gradient--and full-response feedback in computer-assisted instruction. The Journal of Educational Research, 1968, 61, 195-199.

Gilman, D. A. A comparison of several feedback modes in a computer-assisted adjunct auto-instructional program. School of Education, Indiana State University, Terre Haute, Indiana, 1968a (mimeo).

Gilman, D. A. The effect of feedback on learner's certainty of response and attitude toward instruction in a computer-assisted instruction program for teaching concepts. School of Education, Indiana State University, Terre Haute, Indiana, 1968b (mimeo).

Silberman, Coulson, Melaragno and Estavan (1960) studied the effects of branching and fixed-sequence instruction in a CAI program on logic. Thirty-six college students served as Ss. Branching students received a sequence determined by their errors. Fixed sequence Ss were paired by ability level with branching Ss and each number 2 member of the pair then received a program in the sequence order of his branching mate. The difference between groups on the criterion test of achievement was not significant.

Wodtke, Brown, Sands, and Fredericks (1968) used undergraduate Ss and CAI programs on modern mathematics and speech pathology to investigate the effects of logical and scrambled frame sequence in CAI. The modern mathematics program was judged to be conceptually structured and therefore judged to require a logical frame order while the speech program consisted of discrete concepts which would not be as dependent on logical sequence. There were no significant post test differences between the logical-order and scrambled sequence groups in either subject matter, but the logical-order group performed significantly better on the modern mathematics program (structured) than did the scrambled group in terms of errors and time on the program.

Gilman and Gargula (1967) studied the effects of linear and branching sequences in a physics program on dimensions analysis. The branching program included remedial frames which were used only when Ss made errors. Ss were adults who took slightly over an hour to go through the program and who were divided into braching and linear treatments. There were no significant differences in post test performance between groups, but branching Ss used significantly more frames.

Silberman, H. G., Coulson, J. E., Melaragno, R. J., and Estavan, D. P. Fixed sequence vs branching in a computer-based teaching machine. Systems Development Corporation, Sp-195, 1960.

Wodtke, K. H., Brown, B. R., Sands, H. R., and Fredericks, P. The effects of subject matter and individual differences on learning from scrambled vs. ordered instructional programs. A paper given at the American Educational Research Association annual meeting, 1968.

Gilman, D. A. and Gargula, C. Remedial and review branching in computer-assisted instruction. In H. E. Mitzel and G. L. Brandon (Eds.) Experimentation with computer-assisted instruction in technical education. Project report to OE, project no. 5-85-074, The Pennsylvania State University, 1967, 49-58.

Section III

Studies Involving Instructional Effectiveness, Time and Student Attitudes

In this section several statements are made concerning the instructional effectiveness of computer-assisted instruction, and student attitudes towards computer-assisted instruction. Following each statement is a list of studies which may be interpreted as generally supporting the statement.

There are abstracts in the appendix for those studies listed here for which a complete report was available. Many of these abstracts indicate that the studies are weak in terms of experimental design, numbers of students participating, and the duration of the instructional treatment. The criterion for listing other studies here was based on available summaries of CAI research.

A. Instructional Effectiveness

Since computer-assisted instruction is a relatively new instructional technique, the number of well-documented comparative experiments is somewhat limited. However, the studies that have been made have demonstrated either superiority or at least the equality of computer-assisted instruction when compared to conventional methods.

Ash, W. and Moller, Nancy "Teaching Modern Mathematics--Conventional vs. Computer-Assisted Instruction." A technical report, Educational Psychology Section, Purdue University, 1967 (mimeo).

Feldhusen, J. F. and Chavers, Elaine "Evaluation of a CAI Program to Teach the Flandus Interaction Analysis System." A technical report, Educational Psychology Section, Purdue University, 1968 (mimeo).

Grubb, R. E. and Selfridge, L. D. "The Computer Tutoring of Statistics: A Preliminary Report." IBM Research Report, RC-724, Thomas J. Watson Research Center, Yorktown Heights, New York, 1962.

Hansen, Duncan N.; Dick, Walter; Lippert, Henry T., et. al. "Research and Implementation of Collegiate Instruction of Physics Via Computer Assisted Instruction." Computer Assisted Instruction Center, Florida State University, Tallahassee, Florida, Volume I, Technical Report No. 3, November, 1968.

Hansen, D. N. "Learning Outcomes of a Computer Based Multimedia Introduction Physics Course." Seminannual Progress Report (Florida State University, Tallahassee, Florida, 1967).

Keats., "Definitions and Examples of Feedback in a CAI Stimulus Centered Program." Paper given at the American Educational Research Association annual meeting, 1968.

Majer, Kenneth S., Ph.D., "A Study of Computer Assisted Multi-Media Instruction Augmented by Recitation Sessions." Technical Report No. 1 (The Florida State University, Tallahassee, Florida. CAI Center, (1969).

Mitzel, Harold E., et. al., "The Development and Evaluation of a Teleprocessed Computer-Assisted Instruction Course in the Recognition of Malarial Parasites." The Pennsylvania State University, University Park Pennsylvania, Final Report No. R-17, June, 1968.

Moss, Carl R. and Gilman, David A. "Engineering Economics in The Development and Presentation of Four College Courses by Computer Teleprocessing." (By H. E. Mitzel and others). Final Report: University Park, Computer Assisted Instructional Laboratory, The Pennsylvania State University, June, 1967.

Regan, J. J., "Computer-assisted Instruction: Some Facts and Fancies." In K. M. Wientez, P. H. Dubois, and Gaffney, H. (Eds.) Psychological Research in Classroom Learning. Proceedings of a conference at Washington University, St. Louis, Technical Report No. 13, 1967, 38-52.

Schurdak, John J. "An Approach to the Use of Computers in the Instructional Process and An Evaluation." Fairfield University.

Schwartz, H. A. and Haskell, R. J. Jr., "A Study of Computer-assisted Instruction in Industrial Training." IBM Coporation, Poughkeepsie, Journal of Applied Psychology. 1966, Vol. 50, No. 5, 360-363.

B. Time

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Section IV

Summary

Following are several impressions summarizing the literature cited in this report:

1. Computer-assisted instruction appears to be a viable instructional technique having its capabilities thoroughly grounded in current learning theory. It has the potential for becoming a very substantial instructional innovation; however, it must be emphasized that computer-assisted instruction is still in its experimental (infancy) stage and a long way from actualizing its inherent capabilities.

2. The available evidence indicates that computer-assisted instruction can teach as well as live teachers or other media, that students can learn in less time, and that students respond favorably to computer-assisted instruction.

3. The empirical research reported so far concerning the instructional effectiveness of computer-assisted instruction (in terms of experimental design, numbers of students participating, and duration of the instructional treatments) appears to be less than desirable. It may be that since computer-assisted instruction systems are often being developed and perfected at the same time that research is being conducted, adequate time and money may not be available for implementing well-designed experimental evaluations.

Section V

Appendix

The purpose of this section is to provide abstracts of available studies designed to evaluate the relative effectiveness of CAI as an instructional technique. Each abstract presents: (a) the subject content taught, (b) number and description of students, (c) length of treatment period, (d) criterion instruments used, (e) the problem to be investigated, (f) the procedure of the study, and (g) the stated conclusions. This information is provided so that the validity of the generalizations generated by these studies and other studies cited in Section III may be properly interpreted.

Braunfeld, Peter G. "Problems and Prospects of Teaching With a Computer" Journal of Educational Psychology. 1964, 55, 201-211.

Subject Content:	Computer Programming
Subjects:	On the first day of class nine undergraduate students chosen at random were asked to serve as subjects. These nine students were to attend only the computer sessions, skipping the corresponding lectures. The students usually were scheduled to come in pairs. During a session, each student occupied a booth by himself and worked completely independently on his companion, while monitors, slaved to the students' TV displays, enabled observers to watch the proceedings. At the end of a week, the nine PLATO students rejoined the regular class.
Treatment Period:	Materials corresponding to the first three lectures of a university course were prepared for use with PLATO.
Criterial Measures:	Final exams on the content material.
Problem:	(1) Can instruction be presented effectively via PLATO? (2) Is there a difference in time required by students to complete these respective instructional presentations?
Procedure:	The slide material for the three PLATO lessons was written with the active cooperation of the instructor of the course, L. D. Fosdick. Thus, it was possible to make each PLATO lesson cover almost exactly the same material as the corresponding lecture. At the end of the lesson, each student was given a booklet containing reproductions of all the slides of the lesson (the main sequence together

with all the help sequences), as well as the correct answers to all the questions. This was done so that students could review and restudy the material at their leisure at home and, also, to discourage them from wasting valuable computer time by taking extensive notes during a session.

The pedagogical power of PLATO rests on its ability to ask questions, judge answers to these questions, and take a course of action on the basis of the student's requests. When new material can be presented in a sequence of "well-prosed" questions, some of the material the student needs to know does not lend itself to such presentation. To avoid using PLATO merely to present page after page of text--a possible, but trivial use of the system--the students were sometimes given dittoed booklets of textual material to study at home. They were to bring these booklets with them to the appropriate PLATO lessons, which then became problem sessions in which the students were asked to apply what they had read in problems posed by the machine. (The same booklets were also distributed to the regular lecture students). At the end of a lesson, the students were also given a set of homework problems. At the beginning of the next lesson, they were then required to submit the answers to these homework problems to the machine The homework answers had to be correct before the student could begin the new material of the lesson, but helpf sequences were available for each problem. Thus PLATO can be used for automatically grading homework, helping studetns in trouble, and making a record thereof for the instructor.

Results:

The results indicate that:

(1) the nine PLATO students were typical of the class as a whole.
(2) they had learned the material from PLATO about as well as the other students in the regular class lectures.
(3) many students can grasp the material much more quickly than it is presented in the lectures.

Grubb, Ralph E. and Lenore D. Selfudge. "Computer Tutoring in Statistics" Computers and Automation. 1964, 4, 20-26.

Subject Content: College Level Statistics.

Subjects: Six students from the King's College Briarcliff Manor, New York, served as paid subjects in this pilot study.

Treatment Period: The computer program would permit one or two students to run simultaneously in the same or different courses. All students except two were under instruction for an hour or less a day and generally finished this course module within one calendar week. Two students, however, were exposed to the same material under conditions of massed practice; in one Saturday they accomplished all but one-half of the last chapter in the text.

Criterion Tests: Comprehensive examinations on the subject content The examination was one hour in length, consisted largely of problem solving, and was identical with the examination used by the senior investigator (author).

Problem: To examine the relative performance and instruction time required for six students in computer-controlled statistics.

Procedure: The statistics course consisted of a sequence of questions, answers, error cues, reading assignments, and other information stored in the disk file plus a generalized computer program. The latter made decisions regarding the student's progress throughout the course.

In actual practice, the computer selects a question or problem from the instructional program of the course. Each one may have as many as ten alternative answers. These answers may be considered multiple-choice responses, or as acceptable forms of constructed responses. If the student answers correctly, he is told so by name, "Right, John", and the next problem or reading assignment the close of the instructional period. This review was accomplished by permitting the students to use the text in whatever way they wished. The mean review time was 26 minutes.

The mean performance on the examination administered after the review was 94.3 points of a possible 100.

Table 1

Comparison Of Three Instructional Modes
On Identical Material In Statistics

Instructional Mode	Mean Instructional Time	Mid-term Average	No. of Students	Mean Review Time	Mean Gr. Pt. In. (Grade C= 2.00)
650 computer	5.3 hrs	94.3%	6	26 min.	2.68
Lecture	24 hrs. class 25 hrs, homework	58.4%	8	5.3 hrs.	2.14
Programmed text	12.2 hrs.		8	*	*

* data not available

Table 1 summarizes the results of this study compared with two other modes of instruction. In addition to the author's college psychological statistics course taught under conventional lecture methods, a group using a programmed textbook was also available for study within the IBM Voluntary Education Program. Diary studies served as a means for data collection in both instances.

The mean test performance for the computer and lecture groups over identical material was 94.3% and 58.4%, respectively. Both groups took the same post test.

Since the programmed text group took a different mid-term exam from the one used in this study, those results are not comparable and are not reported here. The professional is typed. A similar procedure applies to incorrect responses except that remedial help is now offered. It should be notes that the student is not merely given the correct answer, but is prompted to it. Remedial instruction may be presented in one of three ways. If the question is presented in multiple-choice form, an error cue specific to the incorrect response is typed and the student tries again until he gets the correct answer. If the question calls for a constructed answer, the student is given a general error cue for each of the first two incorrect responses and a presentation of the full correct solution in case he gives a third wrong answer. This is followed by an alternate form problem or, with constructed answers, the student may be given a set of remedial questions which he must answer, followed by an alternate form of the problem. It should be noted that this general program could be used to teach any other appropriately sequenced course.

If a student requests help, or does not respond within a reasonable time, the computer may type out cues. If the cues are exhausted, it will give the full solution and an alternate problem. The time limit may also be specified for each problem. College students were each seated before a teaching station in a specially constructed classroom at the IBM Research Center. A total of five typewriter teaching stations occupied the room. The nature of the course was explained, and instructions were given regarding procedures with the computer. Since the computer was the sole source of instruction in the course, what went on in the room afterwards was observed by closed-circuit TV.

Results:

(1) The over-all mean instruction time for the students to complete this half-semester's work was only 5.33 hours.

(2) Students were also given the opportunity to review in preparation for a written comprehensive examination administered at and technical backgrounds of this group also make any matched group comparisons impossible. But we may note this group's rate of progress through equivalent subject matter: the mean time spent was 12.2 hours, which is slightly over twice as long as the computer group's instruction. The fastest text student took only 5.5 hours (apparently "reviewing" because of his prior statistical background) while the slowest student took 17 hours. Additional significant data not revealed in Table 1 concerning the programmed text group is an analysis of the enrollment. While 29 people registered for the course, only twelve completed the final exam. The exact cause of the high attrition is not fully known; however, the complaint of boredom appeared with high frequency in the diaries.

Finally, the college lecture group was exposed to 24 hours of classroom instruction with an average of 25 hours of homework reported in diaries.

Hansen, Duncan H., Walter Dick and Henry T. Lippert. Research and Implementation of Collegiate Instruction of Physicas Via Computer Assisted Instruction. Final Report, Project No. 7-0071 Grant No. OEG-2-7-000071-2024. Computer-Assisted Instruction Center, Florida State University, 1968.

Subject Content: College Level Physics

Subjects: The university administration requested that all students selected for the CAI course be given the opportunity to voluntarily elect to participate. Since the majority of freshman at FSU preregister in the summer for the fall term, a pool of 100 students who were both pre-enrolled for Physics 107 and were not participating in other freshman research projects were selected. These Ss were contacted by mail; 67% responded favorably, 6% unfavorably, and 27% failed to respond.

(a) Thirty of the favorable respondents were randomly selected and notified. Due to course changes and a misunderstanding concerning the one-credit physics laboratory course, seven of the Ss dropped from the sample. Since classes had met for two sessions, it was decided not to replace these seven dropouts, although there were numerous volunteers available. There is no reason to believe that the sample of 23 Ss was biased on nonrepresentative of the Ss enrolled in Physics 107.

(b) The comparison group of Ss from the conventional course was selected by matching sex and aptitude entrance scores on the Florida Twelfth Grade Examination of these Ss with those of each CAI participant. Within these matches, randomly sampling procedures were used to match one S from the conventional course with each CAI S.

(c) Another comparison group (N=23) was formed by those students from the conventional course who voluntarily participated only in the CAI practice exercises.

Treatment Period: Eleven week term.

Criterion Tests: Florida Twelfth Grade Examination, Mid-term and Final exams in Physics, Brown Scale on Attitudes toward Computer-Assisted Instruction.

Problem: The major purpose of this research were to prepare and perfect a CAI course in introductory collegiate physics and to compare it with the conventional lecture/demonstration course. The comparison of the two modes of instruction consisted of (a) learning effectiveness of each, and (b) student's reactions to the two modes of instruction.

Procedure: The CAI Ss were allowed to schedule their own time at the CAI center. At the center, their progress was directed by the computer program. This presentation was via a cathode ray tube (CRT, a television-like screen) with an associated typewriter keyboard. Problems and instructions to the student were displayed on the CRT. The S could indicate his response to the computer by typing his answer on the keyboard or by touching a light pen to the appropriate location on the CRT.

A typical lesson in the course began with the student reporting to the computer terminal and taking a short quiz based upon his reading assignment. If the student did not pass the quiz, he was instructed to reread the material and return to take the quiz again. If he was successful, the S was directed to listen to a short lecture on the major topic of the lesson. A special cartridge system provided the audio lecture for the Ss at their terminals. The S was also provided with an outline which included helpful drawings relevant to the lecture. After completing the lecture, the S was quizzed via the terminal on the auido presentation. The S was then directed to a single concept film loop or a PSSC film. The single concept film loop presented demonstrations of some of the major concepts included in the lesson. Outlines were also available for the film loops. If the S was directed to view a PSSC film, he would notify a proctor who in turn would operate the film projector. The S then returned to his terminal to take a short quiz on the film. Based upon the lesson content, the S might be directed to other presentations on various media. At the completion of the entire sequence of instruction, the S was given his next textbook assignment.

Special mid-term and final examination reviews were available on another computer system, the IBM 1440. Since this system utilized only a typewriter terminal, the student-computer dialogue was typed.

Most of the CAI students avergaged about two lessons per visit to the Center; the range was from one to eleven lessons. The only constraint placed upon the students in regard to time was that they had to reach the halfway point in the course by the time of the mid-term examination and complete the course by the date of the final examination. The same multiple choice tests were given to the CAI and lecture classes.

Both the CAI and lecture classes were given the same reading assignments in Elementary Physics.

The CAI computer system functioned primarily as a pacing, quizzing, interacting, and recordkeeping tool. The first activity the student generally performed at the terminal each day was to respond to a four to six-item quiz which covered the textbook assignment which was given to the student at the end of the previous lesson. At the end of this quiz, the student's score was displayed on the screen. If he did not answer the minimum number of questions correctly, the computer instructed him to sign off and come back when he was better prepared to pass the reading quiz.

Results:

(a) The mean length of time required for completion of the course was 10.9 weeks in the eleven-week term. When students are allowed to self-schedule, the course completion outcome tends to contradict the common claim that CAI courses will dramatically reduce the length of academic terms. However, the mean time required to complete the 29 lessons was 23.8 hours of instruction. This represents a seventeen percent savings in instructional time. Considering the fixed durations of the films and audio presentations plus the opportunity for repetition of difficult material, this time savings indicates a significant savings in instructional time.

(b) The learning outcomes as reflected in the final grade assignments for the three groups indicate a marked superiority for the autonomous CAI students as illustrated in Table 1. A correlated "t" test on the sum of the mid-term and final exam scores indicated that the autonomous CAI group was statistically superior to the other two groups, but the difference between the partial CAI and conventional students was not significant. The high proportion of "A" grades in the autonomous CAI group represents one of the few instances in which the upper half of a score distribution shifted under CAI treatment. It is much more frequently found that the lower half of the grade distribution is truncated due to a CAI treatment.

Table 1

Frequency Distribution of Grades for the Three Instructional Groups

Conditions	Grades				Mean Grade
	A	B	C	D	
Total CAI	11	6	6	0	3.22
Partial CAI	6	7	10	0	2.83
Conventional	4	5	13	1	2.52

(c) The attitudinal responses of the students to the Brown Scale on Attitudes Toward Computer-Assisted Instruction indicated a moderately positive reaction to the course. A summary of the questionnaire findings indicates that the students (1) were aware of the constrained dialogue of the CAI materials, (2) tended to guess at times, and (3) had a desire for even more individualization. All of the participants considered the CAI course to be preferable to their corresponding conventional courses.

Personal interviews revealed two especially important reactions. First, all of the CAI participants indicated a personal feeling of greater concept mastery in comparison with their peers. For example, the participants claimed to be better explainers of homework problems in comparison with dormmates who attended the conventional course. The second reaction relates to the man-machine interface issue. All of the participants indicated a preference for the automated typewriter interaction in comparison with the CRT-light pen interaction. While many factors may underlie this unanimous reaction (the flexibility an meaningfulness of the typewriter-presented review material, the opportunity to obtain a personal copy of the problem exercises, etc.), this finding should be investigated in light of the higher costs associated with CRT terminal equipment.

Spring 1968--Field Test

Subject Content: College Physics 107

Subjects: There were three groups of subjects used in this study; two control groups and on experimental group. The first control group consisted of subjects who attended conventional P107 lectures for the quarter and received a four-hour examination review on the IBM 1440 system. The second control group only attended convetional P107 lectures for the quarter. The experimental groups took the entire P107 course via the multi-media approach. These groups were labeled 1440 review, conventional, and CAI Autonomous, respectively. The 1440 review group (N=78) consisted of any subject from the conventional class who volunteered to take the P107 examination review on the 1440 system, while the conventional group consisted of the remainder of Ss in the conventional class (N=141).

The CAI autonomous subjects were selected in the following manner: During registration in the spring quarter, 1968

students signing up for Physics 107 were offered the opportunity to take the CAI P107 course. The first forty volunteers within the pre-set quotes of twenty males and twenty females were accepted. There is no reason to believe that this sample was unrepresentative of the regular course population except that they were willing to participate in the CAI experiment. However, rough polling by show-of-hands in several classes indicated that about 70% of the students taking Physics 107 would have been willing to participate. Thirty-seven of the original forty students selected for the study did in fact finish the course. Of these, twenty were female and seventeen were male.

Treatment Period: Eleven week term.

Criterion Tests: Tests on content material (CAI Physics Test), Watson-Glaser Critical Training Test, Logical Reasoning Test, Skip Destination Test. The choice of relevant tests to measure cognitive and affective factors that might be related to success in the physics course was planned as the first task for the students in the Spring Quarter presentation of the CAI physics course. The tests were selected according to the following criteria: (1) the nature of the physics content, (2) uniqueness of the CAI presentation, and (3) tests that had proven utility in measuring cognitive variables. The selection process was by necessity a partially subjective one; and testing time limitations eliminated many tests (only two, two-hour sessions could be devoted to testing). Seven tests were selected and administered to the members of the CAI experimental group during the first week of the Spring Quarter.

Problem: During the winter quarter, 1968, following the completion of the first study and preceding the second, a number of activities were conducted which significantly affected the Spring version of the CAI physics course. First, the entire course was reviewed in light of the subject performance data, student attitudes about the course, and the logistical problems which had been encountered during the fall quarter. For example, many of the students expressed the opinion that the materials used in conjunction with the 8mm concept films was not adequate to describe the activities depicted in the films. Therefore, all these films were recieved and supporting documentation was greatly enhanced. Other less significant but necessary changes were made throughout the course materials.

A second task which was completed during the winter quarter was the selection of a battery of cognitive and affective tests which were to be administered to the students taking the Spring CAI physics course. The purpose of the extensive testing of the students was not only to better understand the entering abilities of the students, but also to attempt to understand the relationship of prior knowledge and entering aptitudes to success in the CAI course. It was anticipated that correlational and regression analyses would be conducted using these variables. These types of analyses were utilized in order to indicate the relative contribution of entering capabilities and knowledge as well as the learning which actually took place during the course and on the final performance in the course.

Procedure:

The students progressed through the Spring version of the CAI physics course much as the Fall students had. Special evening sessions during the first few weeks were utilized in order to administer the battery of aptitude and personality tests to students; a total of four hours of testing was employed. Following a brief introductory session in which they were oriented to the CAI system, the students were permitted to schedule their own sessions at the CAI Center. The only restriction which was placed upon these students was that they were required to take their mid-term examination on or before the date upon which the conventional classroom received their mid-term. The same type of regulation was used in relation to the final examination. In all other respects, the students essentially set their own pace for their own instruction in the CAI physics course.

Results:

(1) One of the unique features of CAI physics course was that it provided for individual self-pacing. To determine whether, in fact, students utilized self-pacing, the distribution of lessons per session per student was calculated. The summarized data are presented in Table 1. As can be noted, only 27 percent of the occasions when the students were in the CAI Center did they complete only one lesson: 73 percent of the visits resulted in the completion of two or more lessons.

Table 1

Distribution of lessons completed per Session for CAI students

No. of Lessons Completed	1	2	3	4	5	6	7	8	9	10	11
Percent of Time	27	38	17	9	5	0	1	2	1	0	1

(2) In order to determine whether the presentation of Physics via CAI was an effective learning situation, the performance of the CAI autonomous group was compared to the performance of two groups of subjects who had not received this treatment. These other treatment groups consisted of: (1) those students attending only the conventional lectures, and (2) those students attending the conventional lectures plus receiving a four-four hour examination review on the 1440 system. The mean scores for each of the three groups for the mid-term examination, final examination and final grade are presented in Table 2. It may be noted that the CAI autonomous group performed slightly better than the other two treatment groups on the final examination. The one-way analyses of variance for these data indicated, however, that there was no significant difference on mid-term, final exam, or final grade between the three treatment groups.

Table 2

Mean Scores of the Three Treatment Groups on the Mid-term Examination, Final Examination, and Final Grade Distribution

	Mid-term	Final	Final Grade
Autonomous CAI	13.32	23.65	60.62
1440 Review	13.51	22.53	58.57
Conventional	13.53	21.87	57.27

The results indicate that although there was no significant difference in the test performance of the CAI group in comparison to either a conventional lecture group or a group which also reviewed on the 1440, there was a learning time savings of approximately twelve percent.

(3) The post-course interview data reflected a generally positive attitude on the part of the students. The course organization was highly satisfactory and none of the course concepts were judged to be unduly difficult About half the students preferred the 1500 CRT system, 27 percent preferred the 1440 typewriter system, and 23 percent had no preference.

Majer, Kenneth S. A Study of Computer Assisted Multi-Media Instruction Augmented by Recitation Sessions. Institute of Human Learning, Florida State University, Tallahassee, Florida, 1967.

Subject Content: College Physics 107

Subjects: Twenty-two (22) Ss taking the CAI/Media course supplemented by recitation, and a control group of 225 volunteers from the traditional physics lecture course. The latter were paid volunteers who agreed to take the examination and complete the questionnaires for one dollar per hour. (Ss may not have been representative of the population from which they were chosen,)

Treatment Period: Ten week. Twenty of the twenty-nine lessons included a PSSC film with running time of 20 to 30 minutes each.

Criterion Tests: Twelfth grade physics examinations, physics pretest, scales from the College Student Questionnaire, Physics 107 final exams.

Problem: (1) To investigate the relative effectiveness of the CAI/Media course when compared with the traditional lecture course.
(2) To determine who are the greatest beneficiaries of the CAI/Media course, the bright or not-so-bright students (as measured by the physics pretest).

Procedure: The CAI physics course followed the same general outline of the companion course taught by lecture. The CAI students were allowed to schedule their own time at the CAI center. At the center their program was paced by the computer terminal. The computer terminal functions primarily as a pacing, quizzing and record-keeping system. This terminal consisted of a cathode ray tube (CRT), a television-type screen, with a typewriter keyboard. Problems and instructions to the student were displayed on the CRT. The student could indicate his response to the computer by typing or touching a special light pen to the appropriate portion of the CRT.

The usual pattern of the course involved the student's first reporting to the computer terminal and taking a short quiz over the reading assignment. If the student did not

pass the quiz, he was instructed to reread the material and return to take the quiz again. If successful, the student was directed to listen to a short audio lecture on the topic being considered. A special cartridge system piped the audio lecture to the students at their terminal. Also, the student was provided an outline which included helpful drawings relevant to the lecture. Completing the lecture, the student would return to the terminal for a quiz on the audio presentation. The student would then be directed to a single concept film loop or a PSSC film. The single concept film loop presented demonstrations of some of the major concepts included in the lesson. Outlines also were available for the film loops. If the student was directed to view a PSSC film, he advised a proctor who ran the film. The student returned to take a short quiz on the film. Depending on the lesson, the student might be directed to other presentations on various media. At the completion of the entire sequence of instruction, the student was given his next textbook assignment. Both treatments received the same reading assignments in Elementary Physics.

Most students averaged about two lessons per visit to the CAI center but ranged from less than one to eleven lessons. The only constraint placed on the students in regard to time was that they must reach the half-way point by midterm and end the course by final time.

Results: (1) Ss in the CAI/Media course performed as well as the Ss instructed by conventional lectures when the dependent measure is the traditional lecture-based final exam.
(2) Brighter Ss achieved to a greater degree than did the not-so-bright Ss.

Morrison, H. W. and E. N. Adams. "Pilot Study of a CAI Laboratory in German" Modern Language Journal. 1968, 52, 279-287.

Subject Content: College Level German

Subjects: Twenty-five (25) students received instruction via the audio-lingual method (ALM).

Treatment Period: Students in the CAI section meth their instructor for three 50-minute class periods each week. Students in the ALM section had three class meetings and two 25-minute conventional language laboratory periods scheduled each week and used a text designed for ALM instruction.

Problem: The students in the CAI and ALM sections were compared in terms of language aptitude, overall academic achievement, course grades, tests of German achievement at the end of the course, and student opinion of the two kinds of laboratories.

Procedure:

The CAI section was taught via the direct method including audio-lingual pattern drills. There was no written homework and practically no class time was spent on writing, translation, spelling, vocabulary, or reading. Recitation which emphasized facility in writing German was scheduled for two 50-minute periods each week at a CAI instructional station. Students could schedule additional time if terminals were available.

In the CAI laboratory each student proceeded at his own pace, working on one unit of instruction at a time and going on to the next unit only after satisfactory proficiency had been demonstrated. Students were encouraged by their instructor to complete the exercises and to maintain progress if they fell behind, but they were not required to do any CAI work and they were told that performance scores from the CAI exercises would not be used in determining their course grades.

Audio-lingual method (ALM). For purposes of comparison, data were collected from a second introductory German section in which the same instructor, Professor Ruplin, taught by the audio-lingual method (ALM) used in all other sections at Stony Brook. This ALM section had three class meetings and two 25-minute conventional language laboratory periods scheduled each week, and used a text designed for ALM instruction. It was intended at the beginning of the year to compare final achievement of students in the two original sections. For this reason students were assigned to both sections through the normal registration procedure, which is effectively random.

CAI laboratory vs. conventional language laboratory--other important differences were: textbooks (hence linguistic content), method of classroom instruction, examinations (different, because texts and methods were different), and possible effects of novelty on motivation. In addition, because of the turnover in the ALM section noted above, in effect, pre-testing was done on one ALM section, post-testing on a different one.

Taken together, results suggest that the students in the CAI section:

(1) were comparable to those of the ALM sections in language aptitude and general academic achievement;
(2) without using the conventional language laboratory acquired the skills of speaking and listening about as well as ALM students;

(3) without specific classroom instruction in reading and writing acquired these skills as well as or better than ALM students.

An Extended Study:

Table 1

First Semester Grades

	W/I	F	D	C	B	A	
Stony Brook ALM students outside study	12%	10%	12%	25%	28%	13%	(N=226)
First-Semester ALM section	4%	22%	13%	30%	22%	9%	(N=23)
Second-Semester ALM section	-	-	6%	29%	35%	29%	(N=17)
First-Semester ALM students who registered for second semester	-	-	7%	43%	36%	14%	(N=14)
CAI section	4%	0%	8%	38%	35%	15%	(N=26)

Table 1b

Second Semester Grades

	W/I	F	D	C	B	A	
ALM students outside study	14%	3%	8%	31%	26%	18%	(N=163)
Second-Semester ALM section	6%	0%	24%	35%	24%	12%	(N=17)
First-semester ALM students who registered for second semester	14%	7%	14%	36%	21%	7%	(N=14)
CAI students who registered in CAI second semester	17%	0%	17%	33%	21%	12%	(N=24)

In summary the above comparions indicate that within sampling errors in the data:

(1) The CAI and first semester ALM students are comparable on both GPA and language aptitude.
(2) The second-semester ALM students are comparable to or slightly superior to the CAI students on the basis of GPA, and to first semester ALM students on the basis of German grades.

Results: Significant differences were found to exist:
(1) On speaking, both the CAI group and the ALM group were higher than the test standarization group.
(2) On writing, the CAI group was higher than both the ALM group and the standardization group.
(3) On reading, the ALM group was lower than the standardization group ($p < .06$).

Schurdak, John J. "An Approach to the Use of Computers in the Instructional Process and An Evaluation" American Educational Research Journal. 1967, 4, 59-73.

Subject Content: A portion of a computer course in Fortran.

Subjects: The students were 48 graduate and undergraduate students in the summer session at Columbia University. Some of the students were enrolled for a voluntary course in FORTRAN to be taught by Columbia staff. Other subjects were paid a fixed sum for completing the experimental material. Students were assigned to the three experimentatl treatments on a random basis within each classification (paid-not paid, graduate-undergraduate etc.). Of the sixteen students in each treatment eleven were paid and five were not paid. The computer and conventional text treatments contained eight undergraduates, six university graduates, and two Teachers College graduate students. None of the students had any prior knowledge of any computer programming language. As a group these were able, well-motivated subjects.

Treatment Period: All students worked independently. Since only two computer-controlled typewriters were avialable, students were run in groups of two for all treatments. Students in the three treatments started in their learning task at the same time on the first day of each week. All subjects worked in two-hour sessions, beginning at the same time on successive days, until they had completed the course.

Criterion Measures: Henmon-Nelson Tests of Mental Ability, College Level, Form A, Comprehensive Examinations.

Problem: (1) To investigate the relative effectiveness of three methods of presenting instructional content, i.e., CAI, programmed text, and a "workbook" approach.

(2) To measure the amount of time required by students to proceed through their respective instructional materials.

Procedure:

Three experimental groups were established to learn a portion of a FORTRAN course by three treatments--by computer, by programmed text, and by conventional text. In the first treatment students were required to take the FORTRAN course. With the exception of the McCraken (1961) textbook, all course materials and the course logic were stored in the memory of a computer. Students communicated with the computer system through computer-controlled typewriters, receiving instruction and entering responses through these typewriters.

In the second treatment the students learned the same concepts by using the programmed text written by Plumb (1963). The subjects were instructed to answer the questions following the frames on a separate answer sheet, before noting the correct answer on the following page, and to work the small number of drill exercises and the relevant questions on an examination provided in the text. The answers to these questions were also provided on a following page.

In the third treatment the subjects studied the identical concepts in what may be described as a "workbook" approach. They were required to read a chapter in McCracken's (1961) text until they felt they understood the material, then to work the problems at the end of the chapter. They were instructed to put their responses to these problems on separate answer sheets before looking at an augmented list of correct answers contained in the back of the book.

Results:

(1) The CAI group scored eleven percentage points, over one standard deviation, higher than the programmed text group, which in turn performed approximately six percentage points higher than the textbook group.
(2) The differences in times to complete learning of the Fortran materials are not reliable.

Discussion:

The computer-taught students received a large step presentation, followed by questions and by immediate effective correction procedures. They did significantly better than those who received either a large or a small step presentation, followed by questions and simple immediate knowledge of the correct results. This suggests that for the learning of this type of material it is the effective correction procedure, rather than theinitial step size or simple immediate feedback that is crucial.

The computer can apparently successfully perform at least partially some of the instructional functions. It can perform the function of presenting new material by providing a controlled presentation of subject matter. It can perform a testing function by continually examining the student concerning his comprehension of the material just studied. It can perform a guidance function, by analyzing such test results and then making decisions concerning future presentations to the student. It can perform a remedial function by identifying the areas of need for such special attention, and presenting the student with drill problems and appropriate small step learning materials. All of these functions may be performed on an individual basis for each student.

Schwartz, H. A. and R. J. Haskell, Jr. A Study of Computer Assisted Instruction in Industrial Training. Journal of Applied Psychology. 1966, 50, 360-363.

Subject Content: Fundamentals of Data Processing

Students: One hundred four newly hired electronic techniques--all were graduates of a civilian or an Armed Forces technical program. Seventy-nine technicians received training via programmed tests. Twenty-five received the same training through a keyboard operated terminal device linked remotely to an IBM 1440 computer system.

Treatment Period: Eight days (32 actual study hours) were allowed for the completion of the material.

Criterion Tests: Pretest on data processing; a final examination; attitude questionnaire.

Problem: This study was undertaken to test the feasibility of remote computer-assisted instruction as an industrial training technique.

Procedure: Two versions of the course material, a programmed text (PI) and a CAI version were employed in the study. Both versions were authored by L.R. O'Neal, IBM, Poughkeepsie. The programmed text was primarily linear with constructed responses, but also included some multiple-choice responses and branch points. The text was authored in 1963 an has been used widely within IBM. The CAI version of the course was designed to accomplish the same objective as the programmed text, but included numerous system-controlled branches and skip options.

The study was conducted between October 1964 and May 1965. Upon reporting to work at the IBM Main Plant, Poughkeepsie, New York, the students, as one of their initial assignments, were required to complete the "Fundamentals of Data Processing" course. The students were divided into two groups. There were 79 students who took the course via programmed texts, the currently operational mode of presentation for this course.

The same course was taken by 25 students via the computer-assisted instruction method. The limited number of CAI terminals available for the study precluded a more even division of students to the two groups.

The programmed text students studied in a classroom under the supervision of a monitor. The CAI students studied in a separate room housing the terminals and were also monitored.

The students studied during the first four hours of the second shift. During the remaining four hours of the day they attended conventional lecture classes on unrelated subjects. Eight days (32 hours) were allowed for the completion of the material.

Before beginning the course, each student was given a pretest to determine his initial level of knowledge of data processing. Upon completion of the course, each student was administered a final examination to evaluate the level of proficiency attained. Prior to the administration of the final examination, each student was asked to complete an attitude questionnaire to determine his attitude toward his respective technique of study as compared to a regular classroom procedure.

Results:

The achievement scores and course completion times for the two groups are presented in Table 1. The difference between the two groups ($p > .05$). Therefore, it may be assumed that in terms of knowledge of course-related data-processing information the groups were equivalent at the outset of the course.

Table 1

Examination Scores and Completion Times

ITEM	CAI		PI	
	M	SD	M	SD
Pretest	12.3	13.3	16.8	13.0
Final examination	86.5	7.7	86.1	9.1
Hours to completion	22.4	4.6	25.1	6.1

Final examination scores of the two groups did not differ significantly ($p > .05$). Thus, the two instructional methods appear to be equally effective in accomplishing their objectives. This outcome is readily understandable, inasmuch as both the CAI and the PI presentations were designed, pretested, and revised to meet certain specified objectives. Since these objectives were the same for both the courses and since the final examination justifiably tested for the accomplishment of these objectives only, no real difference in examination scores would be expected. In any event, the uncertainty involved in the intrepretation of most achievement test scores would tend to vitiate the meaningfulness of any differences unless quite large.

Time, however, is another matter. In the industrial world, time is rather directly translatable into economic factors, and therefore any saving in time is noteworthy. Table 1 shows that there was approximately a 10% difference in the amont of time required to complete the course, 22.4 hours for the CAI groups as compared with 25.1 hours for the PI technique. This difference was statistically significant ($t = 2.35$, $df = 103$, $p < .05$). Since the course content was essentially the same, it is likely that this time saving was due to the pretesting and system-controlled braching features built into the CAI presentation, which permitted the CAI students to propel themselves through the material more rapidly than the PI text students who, due to the nature of that medium, were forced to proceed in a more uniform sequence.

Table 2 presents the results of the objective portion of the attitude questionnaire. In this portion the student was presented with four questions concerning his feeling toward his particular method of instruction (CAI or PI). The student indicated his choice by checking the most appropriate of five statements following each of the questions. According to the statement checked, a scale value was assigned. The value ranged from 1 (indicating negative feelings toward his own method) through 5 (indicating positive feelings toward his own method).

It may be seen in Table 2 that both groups of students considered their respective methods of instruction as approximately equal to the classroom in both effectiveness and desirability. The Median test revealed no significant difference between the two groups for any of the four questionnaire items.

Table 2

Mean Scale Values On Attitude Questionnaire Items

Questionnaire Item	CAI	PI
In your opinion, how well were you taught the material covered?	3.0	3.0
In your opinion, how difficult is it to learn through CAI/PI study?	3.1	3.0
Which method of teaching do you like best?	2.8	3.0
If you had your choice, which method would you use in future courses?	3.1	3.0

Thus, form the standpoints of educational effectiveness and student acceptance, the results of the study indicate the feasibility of computer-assisted instruction as a means of industrial training.

Schwartz, H. A. and H. S. Long "A Study of Remote Industrial Training Via Computer-Assisted Instruction" Journal of Applied Psychology. 1967, 51, No. 1, 10-16.

Subject Content: Computer Technology: Fundamentals of Data Processing.

Subjects: Forty field engineers participated in the study as students.

Twenty-four were assigned to the CAI treatment, sixteen to the self-study programmed test format.

Treatment Period: Six months. CAI students were ordinarily scheduled for study sessions of two hours duration, five days per week. In some cases, however, impending dates for education-center classes forced more extensive study periods.

Self-study students were less formally scheduled and supervised but were encouraged to spend at least two hours of each working day in study.

Criterion Measures: Achievement. The achievement measures consited of the scores attained on Parts II and III of an independently prepared, four-part final examination (Parts I and IV were not related to the study course material). The examination was multiple-choice in format and was administered to the students by the monitor. Part II consisted of twenty-five questions and Part III of ten. Each part was scored independently on a 100-point scale.

Time. Monitors maintained continuous records of on-job study time for the CAI students. Any off-job time is spent in study (e.g., reading reference manuals) was reported on a questionnaire completed by the CAI students. The self-study students were supplied with a special form, on which they made dialy recordings of their on-job and off-job study time and which was returned to the monitor.

Attitude. At the end of the course, but prior to the final examination, each student completed an attitude questionnaire. This questionnaire solicited his comments on both the course material and the instructional method and also required him to compare his instructional method with other techniques.

Problem: Examination scores, course completion time, and attitudes of the students in the CAI group were compared with those of the students who received the content through self-study texts.

Procedure:

CAI system. The CAI system employed in the study was an IBM 1440-1448 system. The student terminals were of two types: one type consisted of a typewriter-like device on which the student could receive typewritten messages from the computer and could type his own messages to the computer. Visual material portions of the course text were contained in a separate book to which the student was referred, when necessary, by a typewritten message. The other type of terminal consisted of both the typewriter-like device and an associated stored-image visual display device. The required visual and textual material was presented to the student under the control of the central computer. With both display and non-display terminals, the student responded to the system only via the terminal keyboard.

In keeping with its original intent--that of determining the feasibility of CAI as a means of accomplishing the required training without removing the student from his work location--the study was conducted under generally normal working conditions. In each location a monitor was designated to be responsible for operation of the terminal, the registration of students, maintenance of records, collection of data, and the establishment of study schedules.

As part of their normal educational sequence, students were assigned by their managers to complete the pre-school course. Although a number of students might be taking the course at any given time, the original assignments were generally made on a one-at-a-time basis. When the assignment to the course had been made, the student was then further assigned to either the CAI or self-study technique of instruction by the study monitor. in the assignment and attempt was made to fully utilize the CAI terminal in each location. Thus, for each student an attempt was first made to assign him to CAI. Where the terminal was not available at the time required by the student's schedule, he was assigned to the self-study group.

Results:

(1) CAI students scored lower on one part of the examination, but completed the course in considerably less time than the self-study students.
(2) Attitude scores were somewhat equivocal. Students who had been exposed to both CAI and self-study text indicated a strong preference for the former.

Smith, Authella Report of the Evaluation of Mathematical Preskills. The Laboratory for Computer-Assisted Instruction, The University of Texas at Austin, 1970.

Subject Content: College Level Math (Exponentiation)

Subjects: Two hundred fourteen students were paired and the pairs performed at the terminal at the same time. Data reported based on pre- and post-test performance of 132 students.

Treatment Period: Ninety minutes--average.

Criterion Test: Pre- and post-tests on the subject material.

Problem: To measure students' achievement of content presented via CAI.

Procedure: Pairs of students at the terminal as the same time.

Results: Individuals with very low initial scores improved considerably. As the test only had twenty-five items, those individuals with very high initial scores had no room for improvement, but in general, there is a marked tendency for gain to be negatively associated with initial performance (linear correlation--.59). The author claims that individuals who are diagnosed as being seriously deficient can expect to improve their performance consideably at least on a percentage basis.

* * *

Subject Content: College Level Math (Exponentiation).

Subjects: Ninety-eight Engineering Freshmen.

Treatment Period: Seventy-eight minutes--terminal time.

Criterion Tests: Pre- and post-tests on the subject material.

Problem: To measure students' achievement of content material.

Procedure: The timing information was obtained from each student's user file which is maintained on disk.

It is supposed to reflect the total amount of terminal time. Due to a system problem, however, some of the times carried in the users file were apparently inaccurate. Every student response is written on tape with an indication of latency time. The latency times were accumulated for each student and the latency times were compared with the times from the user file. In order to obtain some measure of pre-post test performance without disrupting class activity, certain of the diagnostic test items were defined as pretest items and a parallel set of items were programmed for administration after instruction in each segment. If a student's diagnostic test performance indicated that he did not need instruction, his pretest score was arbitrarily assigned as the post test score.

Results:

Results indicated that post test means were uniformly higher than pretest means, but only by a small amount. Pretest performance was so high that little room was available for improved performance. Either freshmen engineers are generally not deficient in this area of mathematics (i.e., exponentiation), or the test items were much too easy.

As the diagnostic test (and thus the pretest) was presented just before each segment, a part of the performance of those students who took all four segments can be attributed to the fact that four the later segments, they may have received instruction on the earlier segments.

The number of students making a perfect score (34) doubled (70) from pre- to post-test, but the one student who appeared to have difficulty raised his score by only two points (9 to 11). This student spent 58 minutes at the terminal. As a comparison, the student who raised his score from 14 to 19 spent over three hours at the terminal. The course is programmed so that a student may skip an item if he wishes. A student who demonstrates deficient performance along with minimal terminal time has usually just skipped items, reflecting (probably) a lack of motivation. The students in this study were required to take Preskills, but they were not graded on the quality of their performance.